INERTIAL CONFINEMENT FUSION
Lawrence Livermore National Laboratory

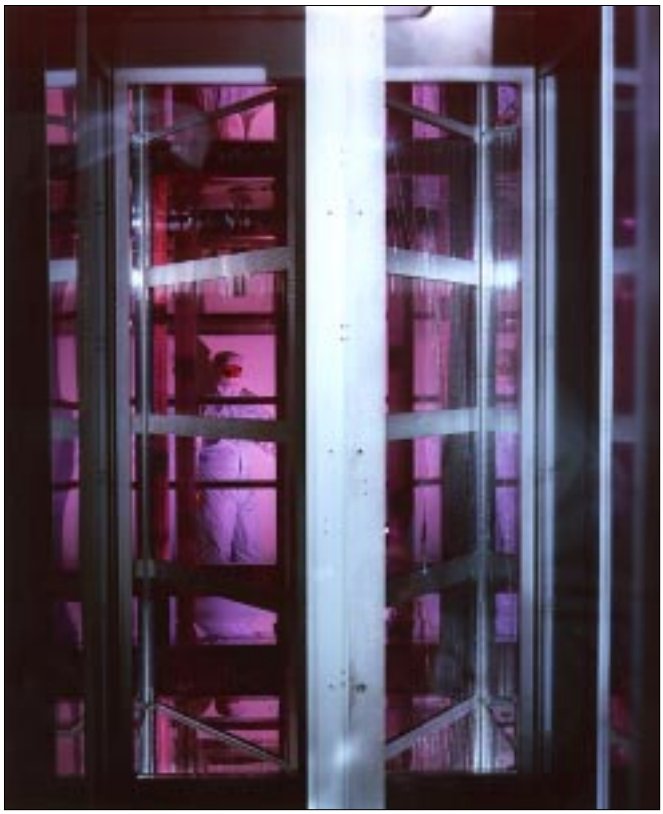
Monthly Highlights

September 1997

UCRL-TB-128550-97-12

Nova as a "20-Beam" Laser. We have effectively doubled the number of beamspots on Nova by propagating two different pulse shapes on each half of the 10 Nova beamline split-glass amplifiers. Using a single lens, the pulses from each half are partially defocused at the target plane to provide two adjacent beam spots with a continuously adjustable power ratio. Applied to a cylindrical hohlraum target, this "20-beam" Nova variant provides a NIF-like two-ring irradiation geometry for testing advanced symmetry control concepts required for achieving ignition.

NIF AMPLAB. We have performed gain measurements on a full-size 4-slab-high × 2-slab-wide × 1-slab-long prototype amplifier with a flashlamp pump cavity nearly identical to the NIF baseline amplifier design. The results, which were in excellent agreement with 2D ray-trace code predictions, are consistent with the NIF amplifiers achieving an aperture-average gain coefficient of 5%/cm. The prototype amplifier, shown below, had a full complement of laser glass and was outfitted with specially shaped flashlamp reflectors and antireflective coatings on the blastshields to increase pumping efficiency.

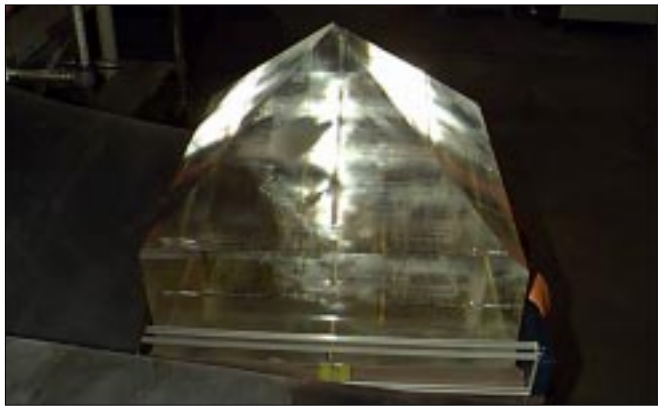


The assembled amplifier seen from the north mirror tower.

NIF Construction. NIF construction packages for the site preparation, foundations, the laser building shell, and the optics assembly building were awarded on schedule. The first contract (under $1M) was awarded to Red Top Construction of Hayward, California. Digging the "big hole" was done by Teichert Construction of Stockton, California, in a contract under $2M. The third contract, of $4.2M (to do the foundation and concrete slab work) was awarded to Walsh Pacific of Monterey, California. The $11.4M contract for constructing the laser building shell was awarded to Neilson Dillingham of Pleasanton, California. Preparations for the remaining construction contracts are proceeding on schedule.

NIF KDP Rapid-Growth Program. Over the last few months, a great deal of progress has been made in the rapid growth of KDP and KD*P (deuterated) crystals for the NIF. Shown below is a KDP boule measuring 57 × 57 × 47 cm, which is the minimum size required for NIF second-harmonic-generation crystals. Larger, crack-free, and higher-optical-quality crystals resulted from thermal expansion coefficient matching of the growth-platform base plate to the crystal material. An additional KDP boule measuring 55 × 55 × 38 cm was grown with a continuous filtration system installed and operating for the duration of the run. Crystals grown in small tanks with continuous filtration have been tested and show a significant improvement in damage threshold over those grown without constant filtration.

A KD*P boule measuring 52 × 51 × 38 cm has also been grown, but it does not have sufficient height to yield a third-harmonic-generation plate. Experiments are under way to increase the aspect ratio of these crystals. We have demonstrated NIF damage thresholds in small KD*P boules, but have not yet evaluated the 52-cm boule. The large crystals still contain some inclusions, so work continues on improved system design and process optimization.



57 × 57 × 47-cm KDP crystal.

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Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

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Monthly Highlights

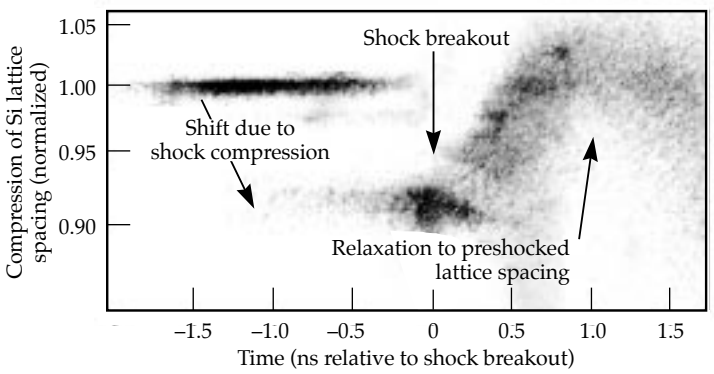
October 1997

UCRL-TB-128550-98-1

NIF Site Preparation on Schedule. The NIF construction and site preparation activities have continued on schedule for Project completion at the end of 2003. The excavation is 95% complete. Shown below is a photo of the target area excavation pit as seen from the future location of the NIF control room.

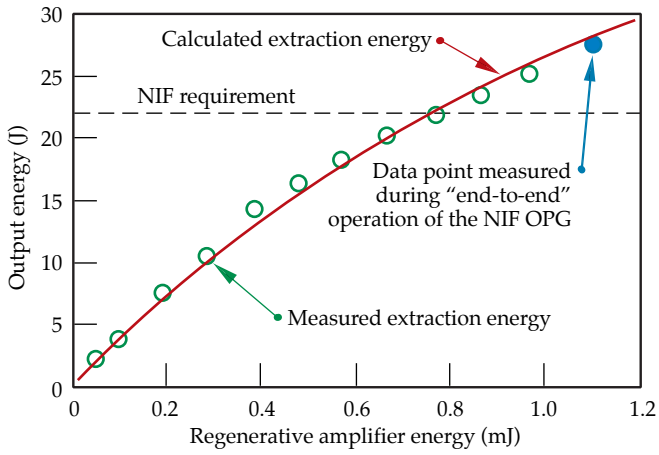
NIF target area excavation pit.

Dynamic Bragg Diffraction on Nova. Solid-state shock-compression experiments are being done on the Nova laser to study the transition from elastic to plastic deformation under shock compression. We are using Bragg diffraction to characterize the shock-wave profile inside shocked single-crystal samples. A low-temperature hohlraum drive shock-compresses the single-crystal silicon samples. Both time-integrated and time-resolved Bragg-diffracted x rays are then recorded to measure the compression of the 2D lattice spacing along the shock propagation direction (see figure below). We have observed compressions of up to 10% in one dimension in (111) silicon at 500-kbar drive pressure, and we are developing the capability to probe orthogonal lattice planes simultaneously. The Bragg diffraction work is being done under the Science (University) Use of Nova program in collaboration with scientists from the University of California at San Diego, the University of Oxford, and Los Alamos National Laboratory.



Time-resolved Bragg-diffracted x rays from shocked silicon.

Demonstration of NIF Optical Pulse System. We have successfully demonstrated operation of a NIF-like integrated optical pulse generation (OPG) system comprising an advanced master oscillator, a new regenerative amplifier, and a new 4-pass amplifier. These system components individually and in integrated operation now meet or exceed the NIF specifications for input to the main laser amplifier cavity in critical areas such as output energy, wavefront, contrast ratio, and square-pulse distortion. The master oscillator uses a fiber-based oscillator and NIF prototype fiber amplifiers. Its output of 180 pJ is delivered via a fiber-optic cable to the regenerative amplifier. We have achieved as much as 30 mJ of output from a new design of the "regen" amplifier with acceptable square-pulse distortion employing only a single diode-pumped head. The 4-pass amplifier has been designed using the 50-mm Nova-type rod amplifier. With this OPG system, we have produced integrated results at output energies well beyond the NIF requirement of 22 J with as small as 1 mJ from the regen amplifier (see graph below).



Demonstrated operation of the optical pulse generation system above the 22-J NIF requirement.

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November 1997

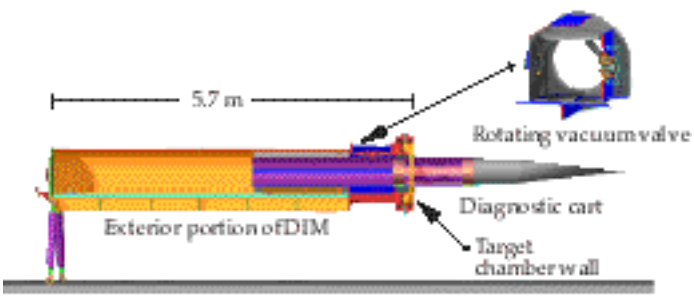
UCRL-TB-128550-98-2

NIF Construction on Target. Activities for the construction and site preparation (see below) of the National Ignition Facility (NIF) remain on target this month for completion in 2003. Five construction packages have been awarded to date; the remaining three will be awarded in the coming year.

An aerial view of the NIF site (November 1997).

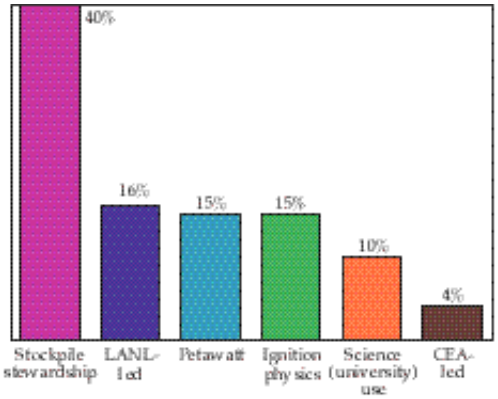
Diagnostic Instrument Manipulator (DIM).

The DIM being designed for NIF will allow insertion of a variety of diagnostics into the target chamber while under vacuum. This design is part of the collaborative effort between the ICF Program and the Atomic Weapons Establishment (AWE) in England. Engineers from AWE presented their Title II 35% design review of the DIM to the NIF project in November, and the design satisfied all of the requirements. AWE is planning to construct a half-length prototype of this design and ship it to LLNLin late FY98 for testing and evaluation. We are also evaluating the possibility of testing the prototype DIM on the Omega laser at UR/LLE. To facilitate exchange of target diagnostics between other laser fusion facilities, CEAin France is considering using the AWE DIM design for their LILand LMJ laser facilities.



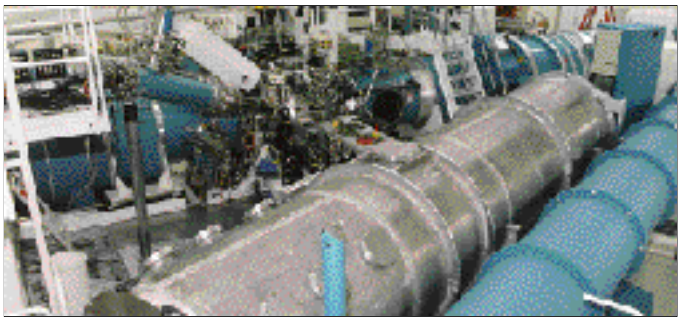
AWE DIM design.

Nova Shot Schedule Set for FY98. In November, LLNL's Council for National Security approved the FY98 schedule for the Nova laser. The approved allocation, shown below, totals approximately 900 shots during the fiscal year. LLNL's contribution to DOE's Stockpile Stewardship Program (SSP) accounts for the majority of the shots. Most of the essential Nova-scale target ignition physics experiments in support of ignition demonstration on NIF are complete. Anew emphasis this fiscal year will be the Petawatt shots, which will be used for high-energy (2- to 8-MeV) radiography for SSP and fast ignitor research for ICF.



Distribution of Nova shots for FY98 (facility shots prorated.)

Nova 2-Beam Target Bay Conversion. The last 2-Beam experiment was performed on November 12. Completed in 1985 with shared funding from LLNL's weapons and laser programs, the 2-Beam facility evolved to support over 1,000 laser experiments in a variety of research areas, promoting novel interactions between the weapons physics and ICF communities. The 2-Beam facility will be converted into the ICF Optics Processing Development Laboratory and will be used to develop high-volume processing for optical elements, which are among the most critical components for future ICF research, including NIF. The new laboratory should be operational by late 1998.



The Nova 2-Beam facility.

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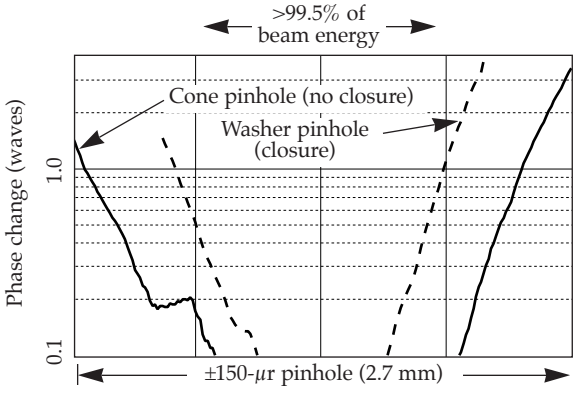
December 1997

UCRL-TB-128550-98-3

NIF Bids Opened; Mammoth Bones Found. Bids from three companies were opened this month to reveal their fixed prices for completion of the NIF Laser Building. Within the next few weeks the NIF Project Team will review the bids in detail to determine whether they respond properly to the bid package and are in conformity with all requirements. Meanwhile, on Dec. 15, a worker at the NIF construction site found the jaw bone of a mammoth. DOE and LLNL have decided to remove and preserve as much of this paleontological find as possible without substantial negative impact to the NIF project schedule.

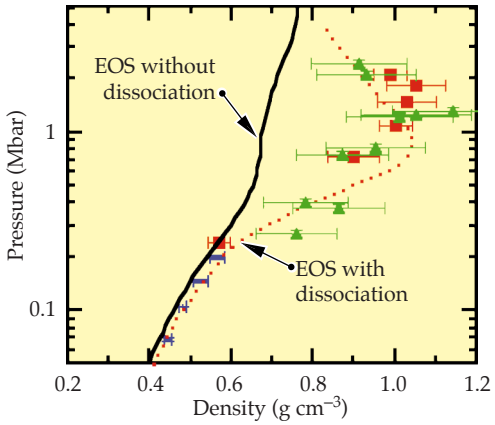
The NIF construction site (December 1997) has been called the largest excavation area in the San Francisco East Bay.

New Pinhole for NIF Spatial Filters. Beamlet measurements have demonstrated a new pinhole design for use on the NIF spatial filters. Spatial filter pinholes "clean up" beams by blocking beam power at the high spatial frequencies. However, the blocked beam power generates plasma, which can expand into the pinhole and disrupt the transmitted beam for multi-nanosecond pulses. The new pinhole is a truncated cone, with the larger opening facing the beam. The high-angle conical surfaces are designed to reflect and refract rather than absorb unwanted beam power, holding the plasma generation to low levels and thus keeping the hole "open" for a longer period of time. The phase change at the end of the pulse and near the edge of the pinhole (solid curves in figure) is significantly less than that observed during pinhole closure (dashed curves), as measured in earlier experiments with a different pinhole design. The Beamlet experiments showed that a ±150-μr (2.7-mm-diam) stainless-steel cone pinhole remained open for the full duration of a 20-ns NIF ignition pulse.



A snapshot of plasma-induced phase change at the end of a "NIF ignition laser pulse" for two different pinhole designs.

Nova Studies of Liquid Deuterium. Using a velocity interferometer, we have improved the accuracy of the shock-speed measurement to better than 1%, and we simultaneously measured for the first time the reflectivity of shock-compressed deuterium. We also implemented a temperature diagnostic that made the first temperature measurements of shock-compressed deuterium in the megabar regime. The results below (green triangles) confirm the earlier Nova data (red squares) as to the important role that molecular dissociation plays in the equation of state (EOS) of hydrogen and its isotopes.



Measured and calculated Hugoniots for liquid deuterium. Blue bars are earlier gas-gun data; green triangles/red squares are Nova data.

APS-DPP Papers Presented. LLNL ICF scientists presented 90 papers at the 39th annual meeting of the Division of Plasma Physics (DPP) of the American Physical Society (APS) in Pittsburgh, Pennsylvania, between November 17 and November 21. Of the 90 papers, 8 were invited papers. Many of the contributed papers were co-authored with other LLNL division scientists and other national ICF Program researchers. Abstracts of these papers can be viewed at LLNL's documents-on-line electronic library at http://www.llnl.gov/tid/lof/lof_home.html by searching for the last name of the paper's first author.

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